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Litter Fauna in *Nothofagus cunninghamii* Forests

By Truda M. Howard*

Abstract: The composition of the litter fauna of *Nothofagus cunninghamii* forests in Victoria and Tasmania is compared. In Tasmania both pure *Nothofagus* and *Nothofagus-Eucalyptus delegatensis* forests were studied at a single sample time. In Victoria pure *Nothofagus* forest litter was sampled throughout the year. Populations ranged from 2000 to 5000/m^2 and consisted predominantly of mites (40-50%), Collembola (11-18%), and dipteran larvae (10-33%), but isopods, amphipods, diplopods, and chilopods formed the greatest part of the biomass. In the Victorian forest mites, isopods, and millipedes were most numerous in spring and summer and dipteran larvae and curculionid beetles in autumn and winter. Populations appear to be smaller than those of Danish or Japanese beech forests but the breakdown of litter is probably more rapid.

INTRODUCTION

There is little published information on the litter fauna of Australian forests. Birch and Clark (1953) based their paper on the study of a rain-forest north of Sydney in which the amphipod *Talitrus sylvaticus* Haswell was considered to be an important element in the fauna. There is also little information on the litter populations of southern beech forests. Some information is given in recent papers by Dutch and Stout (1968) and Wood (1970, 1971).

The present paper records the litter fauna of beech forests and mixed beech-eucalypt forests in Tasmania and Victoria, Australia, and provides further data on the fauna of southern hemisphere forests and a comparison with the previous studies of European and Japanese beech forests.

In Surrey Hills, Tasmania (see Fig. 1) two sites at which *Nothofagus cunninghamii* Oerst. occurs as a forest dominant, and two at which it forms an understorey to *Eucalyptus delegatensis* R. T. Baker were sampled in January 1965. Samples were collected at monthly intervals, from March 1966 to February 1967, from a *N. cunninghamii* dominated site on Mt. Donna Buang in Victoria. These samples were used to compare the fauna of two different adjacent forest types, of geographically separated forests of the same type, and of monthly samples at one site.

PHYSICAL ENVIRONMENT

All forest sites studied occur in Koeppen's CfB climatic type (Trewartha 1943). This is defined as a warm temperate rainy climate, with the average temperature of the coldest month below 18° but above −3°C and the average temperature for the warmest month over 10° and under 22°C. There is no distinct dry season, and the driest summer months receive more than 30 mm of rain.

The annual rainfall for the Victorian site (Mt. Donna Buang, elevation 1006 m) was calculated

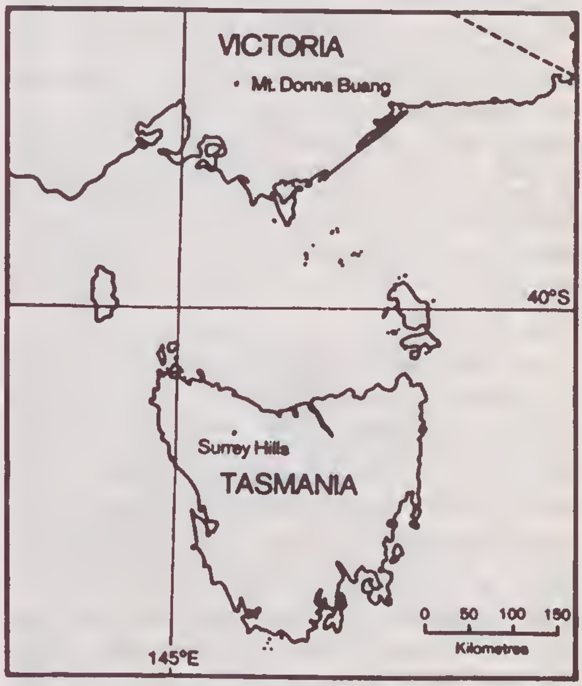

Fig. 1—Litter collection localities in Victoria and Tasmania.

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as 2410 mm (Howard 1970) and that of the Surrey Hills District of NW. Tasmania (average altitude 610 m), calculated on the basis of two years' records, probably exceeds 2000 mm. Snow falls occur but the snow does not persist for more than a few days. The main feature of the temperature regime is the possibility of frosts which may occur throughout the year, but are most prevalent in winter time.

The effect of both rainfall and temperature on the litter layer is modified by the forest canopy, which retards heating and cooling of the air within the forest and intercepts and redistributes the rain, fog or snow.

The Victorian site studied is located on a south facing slope (10°) of Mt. Donna Buang on a deep kraznozem derived from Upper Devonian dacite (Hills 1930).

The Tasmanian stands are growing on kraznozems derived from Tertiary basalt which forms a plateau in the Surrey Hills area. Although the structure of the kraznozems is good, drainage is not always as rapid in the Surrey Hills area as on Mt. Donna Buang. The two forest sites dominated by *N. cunninghamii* are on north and south facing slopes of 11°. The two eucalypt dominated sites are on almost flat terrain.

VEGETATION

(a) *Nothofagus cunnighamii* dominated forests.

The only differences detectable between the Victorian and Tasmanian *Nothofagus* stands were the presence of a few endemic species in Tasmanian stands and differences in the litter and ground stratum. These differences are minimal, as the two land areas were connected during a glacial period between 20,000 and 37,500 years ago (Howard & Hope 1970), if not more recently. In general the floristics and structure of the forest were the same.

Nothofagus forest is dominated by *N. cunninghamii* which forms a closed canopy (crown cover 75%), and reaches a height of 30 m. *Atherosperma moschatum* Labill. (and *Phyllocladus aspleniifolius* Hook. f. in Tasmania) may also occur as part of the tree stratum. The mean density of *N. cunninghamii* in a number of Victorian stands was 600 trees/ha, with a mean basal area of 40 m^2/ha. *Nothofagus* trees are usually single or double trunked, and *A. moschatum* is often multi-stemmed. The crown occupies one half to one third of total *Nothofagus* tree height, and fine branches are present on the remainder of the trunk. Beneath the tree stratum there may be a low (up to 3 m) tree fern stratum (predominantly *Dicksonia antarctica* Labill.) and sometimes a few shrubs [e.g. *Coprosma quadrifida* (Labill.) Robinson]. A ground stratum of ferns, such as *Polystichum proliferum* R. Br. and *Blechnum procerum* (Forst. f.) Swartz may be present. In Victoria the litter layer is thin (1-3 cm) and very disturbed by lyrebird (*Menura novaehollandiae*) cultivation. In this stand the annual litter fall over one year was measured as 7·50 tonnes/ha, with a turnover rate of 42% p.a. In Tasmania the litter is thicker (10-15 cm) and the forest floor is often covered with a deep layer of mosses, lichens and liverworts. Mosses, liverworts and lichens are also a feature of Victorian stands, but there they tend to be confined to dead wood, stones and tree trunks, and do not extend onto the forest floor.

(b) *Nothofagus*—eucalypt forests.

Forests of eucalypts, such as *Eucalyptus regnans F. Muell., E. nitens* Maid. or *E. delegatensis*, when growing in a sufficiently high rainfall area (greater than 2360 mm per annum in Victoria) are likely to be replaced by a forest of *N. cunninghamii*. This is if no fires occur for about 400 years (Howard 1973a), and *Nothofagus* seed is available. Sixty to one hundred years after the invasion of a eucalypt forest by *Nothofagus*, a forest similar to that described above results, except that above the *Nothofagus* closed canopy is a tall (36-46 m) open (15-25% cover) eucalypt canopy, whilst under the *Nothofagus* there may be a straggling shrub stratum [e.g. *Drimys lanceolata* (Poir.) Baill., *Leptospermum scoparium*] up to 6 m tall, and a number of shade tolerant small shrub species. This forest has been called Mixed Forest (Gilbert 1959). Without the intervention of fire, this forest becomes pure *Nothofagus* forest when the eucalypts die (400 years appears to be their maximum age) as they are unable to regenerate in the heavy shade of *Nothofagus* (Howard 1973b).

The litter layer in these forests is fairly deep (5-10 cm). Moss, lichen and liverwort growth is not as common on the ground as in the mature *Nothofagus* forest. At all Tasmanian sites litter accumulation and moss build-up are greatest around the boles of *Nothofagus* trees and in places exceed 60 cm in depth.

SAMPLING AND EXTRACTION OF LITTER FAUNA

Samples of litter were collected at random, except that the litter accumulation around trees and fallen logs was avoided. A spade was used to cut squares 25 x 25 cm. The litter was then scraped rapidly into a plastic bag, and sealed. Care was taken not to collect mineral soil during this process, though in the Victorian forest this was difficult due to the disturbed surface. At the four Tasmanian sites 25 samples were collected from each on a single occasion, and at the Victorian site 15 samples were taken each month.

The litter fauna was extracted as soon as possible by the use of a Tullgren Funnel. A 60 watt lamp held 15 cm above the litter surface provided heat and light, and the fauna was collected in a phial of 70% ethyl alcohol. The litter appeared to be completely dry after 48 hours, and was removed before it started to fall into the phial. The dried litter was weighed.

The fauna was sorted by eye and with the aid of a 20 × binocular microscope; only the larger species were counted. Many groups were not identified beyond the ordinal level, e.g. Collembola, but in some cases more detailed classification was possible. All material has been placed in the National Museum, Melbourne, Victoria. (The identified groups are listed in the Appendix).

The Victorian data was analysed using the Canberra Hierarchical programme (Lance & Williams 1967) MULTBET, under the supervision of Dr. W. Williams.

RESULTS

(a) *Tasmanian forests* (Table 1).

The data show that:—

a. There is little difference between the two types of forest except in the number of insect larvae and the presence at one *Nothofagus*-eucalypt site of a distinctive prostigmatid mite.

b. The most numerous animals were mites, Collembola and insect larvae. Apart from the Collembola, of which at least 5 species were present, the most common adult insects were curculionid beetles.

c. The Isopoda, Amphipoda, Diplopoda and Chilopoda, although relatively few in number, comprised the greatest biomass.

(b) *Victorian forests* (Table 2).

The data shows that:—

a. The three most numerous groups are the mites, Collembola, and dipteran larvae, although the latter are only poorly represented during the spring and summer months and the monthly variation is great. The curculionid beetles were the most numerous adult insects.

b. The Isopoda, Amphipoda, Diplopoda and Chilopoda comprise the greatest biomass.

(c) *Effect of Season and Locality on the Victorian Forest Fauna* (Table 3).

a. A major division occurred between those groups which were most numerous in spring and summer and those most numerous in autumn and winter. Mites, isopods, and millipedes were most numerous in spring and summer; dipteran larvae and curculionid beetles in autumn and winter. A number of groups were of equal importance in all months, and others were too few for conclusions to be drawn from their distribution.

b. The proximity of samples to ground ferns (*B. procerum, Polystichum proliferum* R. Br.) had no appreciable effect on the composition of the fauna. The only relationship observed was that of *Peripatus,* which occurred near rotting wood.

DISCUSSION

One of the most noticeable characteristics of samples taken from the same forest types is the wide variation in the numbers of a particular animal type between samples. This makes statistical comparison between samples on either an area or litter dry weight basis unreliable. The expression of animal numbers in terms of litter dry weight adds little to our understanding of animal density. It is probable that populations cluster at random within the litter layer, and that this is one of the reasons for the very variable number of individuals per sample.

The fauna of all the sites sampled showed general similarity although the level of classification was inadequate for critical evaluation. However, species of Collembola and some mites as well as the amphipod *Talitrus,* appeared to be identical at all sites. Amongst the most interesting insects identified were the *Hemodoecus* spp. (Peloridiidae) which are primitive flightless Hemiptera confined to southern forests (Britton 1957). The methods of sampling tend to underestimate the oligochaete and mollusc populations but the importance of terrestrial isopods and amphipods is characteristic of southern rain forests.

Seasonal variation shown in the Victorian samples is probably due to both differences in life-cycle and vertical migration associated with changing physical conditions, particularly temperature. Changes in the populations of predators such as phalangids, centipedes, pseudoscorpions and spiders, may also reflect changes in the populations of food species. Two kinds of mites, the amphipod and the Collembola remain in almost constant numbers throughout the year, though Collembola show a slight summer maximum. The only major difference between the Victorian and Tasmanian sites, apart from the depth of the litter, is the presence of the lyrebird at the former. The lyrebird cultivates the soil extensively. At the Mt. Donna Buang site records

TABLE 1

THE TOTAL NUMBER OF INDIVIDUALS OF EACH TYPE IN 25 SAMPLES AT EACH FOREST SITE IN FORESTS CONTAINING *NOTHOFAGUS CUNNINGHAMII*, SURREY HILLS, NW.TASMANIA.

Vegetation	*N. cunninghamii* forest				*Nothofagus* - Eucalypt forest			
Number in:	25 samples		1000 g		25 samples		1000 g	
Site:	1	2	1	2	3	4	3	4
Myriapoda								
Diplopoda	75	44	30	13	8	73	2	17
Chilopoda	70	30	29	9	12	14	3	3
Symphyla	3	1	1	0	16	2	4	0
Insecta pterygota (Adults)								
Diptera	116	140	46	45	215	222	61	53
Hemiptera								
Homoptera	6	32	2	9	6	8	1	2
Coleoptera								
Curculionidae	32	31	12	9	34	38	9	9
Neuroptera	2	2	0	0	3	1	1	0
Hymenoptera	0	1	0	0	0	1	0	0
Lepidoptera	4	0	1	0	4	1	1	0
Insecta pterygota (Larvae)								
Chironomidae	542	188	212	56	578	684	161	165
Scatopsidae	72	229	28	72	479	460	130	110
Rhagionidae	49	84	20	25	220	135	62	32
Tabanidae	27	160	11	48	55	39	15	9
Ceratopogonidae	40	24	16	7	39	117	11	28
Lepidoptera	78	64	31	19	117	195	33	47
Others (incl. Coleoptera)	117	59	47	18	169	124	48	29
Insecta apterygota								
Collembola	973	451	345	135	1070	571	303	137
Crustacea								
Malacostraca								
Isopoda	22	70	9	21	11	17	3	4
Amphipoda (*Talitrus* sp.)	139	45	55	10	43	90	12	21
Arachnida								
Pseudoscorpionida	3	4	1	1	1	5	0	1
Araneida	25	37	10	11	75	23	21	6
Acarina (Parasitiformes)								
Mesostigmata (1.	321	142	127	42	5	15	1	3
(2.	118	218	47	62	318	156	90	39
Uropodidae	169	232	67	73	216	886	61	93
Diplogyniidae (Mesostigmata, Antennophorina)	45	8	17	2	54	4	15	1
Sphaeroluchidae (Prostigmata)	0	0	0	0	0	841	0	202
Unknown mites	259	78	103	24	106	21	30	5
Acarina (Sarcoptiformes, Oribatei)								
Galumnidae	207	224	82	70	555	80	150	19
Phthiracaridae	713	542	281	162	621	514	177	121
Oligochaeta	37	19	14	6	16	9	5	2
Total number of organisms	4264	3159	1664	949	5046	5346	1410	1158
% Contribution of Acarina	42.9	45.3	-	-	37.1	47.0	-	-
% Contribution of Collembola	22.8	14.2	-	-	21.1	10.7	-	-
% Contribution of Dipteran Larvae	21.2	25.6	-	-	32.8	32.7	-	-

TABLE 2

TOTAL NUMBER OF INDIVIDUALS OF EACH TYPE PER MONTH IN 15 SAMPLES (25 cm × 25 cm) OF LITTER AT MT. DONNA BUANG, IN *NOTHOFAGUS CUNNINGHAMII* FOREST

Taxa	March 1966	April 1966	May 1966	June 1966	Aug. 1966	Sept. 1956	Oct. 1966	Nov. 1966	Dec. 1966	Jan. 1967	Feb. 1967
Myriapoda											
Diplopoda	15	8	23	64	32	21	18	46	16	46	38
Chilopoda	20	3	23	52	9	43	43	54	6	37	26
Symphyla	4	1	10	17	4	5	13	30	1	7	5
Insecta pterygota											
Diptera (Adults)	203	177	1	0	24	10	74	84	81	13	36
Diptera (Larvae)											
Chironomidae	90	90	12	116	48	62	4	23	14	3	23
Scatopsidae	175	177	103	106	171	70	71	64	6	13	24
Rhagionidae	0	35	24	23	41	27	1	0	1	1	0
Ceratopogonidae	0	0	0	0	0	6	2	102	2	19	1
Coleoptera (Adults)											
Curculionidae	58	58	68	136	130	74	55	47	17	32	33
Scydmaenidae, Pselaphidae	0	4	0	10	16	8	8	6	10	8	7
Miscellaneous Adult Insects	6	1	0	1	3	1	5	6	34	12	8
Miscellaneous Larvae	36	33	21	24	14	36	22	37	6	21	11
Insecta apterygota											
Collembola	150	276	150	186	102	140	187	568	65	155	111
Arachnida											
Pseudoscorpionida	0	0	0	0	0	5	30	28	0	67	32
Araneida	11	14	8	48	31	35	39	62	8	20	18
Acarina											
Mesostigmata	56	18	20	14	76	160	230	28	99	339	142
Uropodidae	53	26	75	124	94	98	223	183	50	257	58
Diplogyniidae	9	7	11	44	22	54	25	41	16	8	6
Cryptostigmata											
Galumnidae	200	28	109	100	58	866	474	386	74	105	286
Phthiracaridae	159	138	166	198	181	231	320	137	82	140	87
Unknown Oribatidae	0	0	0	0	0	43	47	60	44	93	49
Unknown Mite A	111	126	118	72	228	211	274	133	102	221	72
Unknown Mite B	0	0	31	29	47	35	7	27	11	97	54
Phalangida	14	6	26	77	40	55	93	76	9	23	19
Annelida											
Oligochaeta	6	6	4	16	16	13	17	8	0	9	5
Crustacea											
Malocostraca											
Isopoda	59	24	105	180	113	158	199	249	20	111	80
Amphipoda (*Talitrus* sp.)	37	37	72	172	119	140	98	153	20	78	97
Onychophora (*Peripatus* sp.)	0	0	0	3	1	1	2	7	1	0	6
Total number of organisms	1462	1293	1180	1812	1620	2608	2541	2645	794	1935	1333
% Acarina	40.8	26.5	44.9	32.0	43.5	61.8	62.8	37.6	60.1	68.6	56.5
% Dipteran Larvae	18.1	23.3	11.8	13.6	16.0	6.3	3.0	6.7	3.0	1.8	3.6
% Collembola	10.3	21.4	12.8	10.3	6.3	5.2	7.3	21.4	8.2	6.9	8.3

of scratching activity were kept for 15 months and during this time the observed soil surface was cultivated to a depth of 2·5 cm 1·79 times. The cultivation is concentrated on patches of soil without ferns, but the lack of difference between the fauna of ferny and fernless areas in this forest indicates that this scratching is not significant in terms of the litter fauna type or quantity.

Differences in sampling methods and extraction techniques make comparison with published data difficult, but populations, whether on an area or weight basis, appear to be smaller than in New Zealand litter (Dutch & Stout 1968) and the Victorian forest, on an area basis, appears to have a slightly smaller population than the Tasmanian forests. All the southern forests appear to have much smaller populations than the European (Bornebusch 1930) or Japanese cold temperate beech forests (Kitazawa 1967), although the quantity of litter fall appears to be greater and the rate of turnover higher. This is in accord with the view that although less numerous, populations increase in activity with increasing temperature. The other important distinction of the southern forest faunas is the importance of terrestrial amphipods.

TABLE 3

THE DISTRIBUTION OF FAUNA AT MT. DONNA BUANG BETWEEN TWO SEASONAL GROUPINGS (SPRING-SUMMER, AUTUMN-WINTER)

Animals most prominent from Sept.-Feb.	Mean Number per Plot	
	Sept.-Feb.	Mar.-Aug.
Uropodidae	10.948	2.794
Unknown Mite A	22.459	18.757
Unknown Oribatidae	3.639	0.132
Galumnidae	20.711	9.265
Diplogynidae	1.814	0.985
Diplopoda	2.309	1.515
Isopoda	9.784	5.926
Chilopoda	2.876	0.632
Pseudoscorpionidae	1.670	0.147
Phalangida	3.237	1.706
Araneida	2.010	1.471
Animals with no particular seasonal prominence		
Phthiracaridae	22.334	22.989
Unknown Mite B	1.918	2.162
Amphipoda (*Talitrus* sp.)	6.814	5.515
Diptera Adults	3.742	2.809
Collembola	14.464	10.103
Animals of rare occurrence throughout the year		
Oligochaeta	0.729	0.185
Peripatus sp.	0.271	0.074
Pselaphidae + Scydmaenidae	0.557	0.667
Gasteropoda	0.629	0.185
Symphyla	1.000	0.111
Animals most prominent from Mar.-Aug.		
Scatopsidae Larvae	3.557	9.294
Chironomidae Larvae	1.351	5.088
Rhagionidae Larvae	0.206	1.941
Curculionidae Adults	3.289	5.647

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APPENDIX

Abbreviations: x = presence of specimens indicated; Vic. = Mt. Donna Buang, 1006 m, 1966-1967, *N. cunninghamii* forest litter; Tas. = NW. Tasmania, 610 m, Dec. 1964, *N. cunninghamii forest litter.*

	Vic.	Tas.
HEMIPTERA		
Homoptera		
Peloridiidae		
Hemidoecus leai China		x
H. donnae Woodw.	x	
Heteroptera		
Miridae		x
Lygaeidae		
Pachybrachis sp.	x	
Homoptera		
Aphidae	x	x
COLEOPTERA		
Larvae (total)	x	
Cerambycidae		
Anthemistus sp.	x	
Scarabaeidae		
Sericestis sp.	x	
Pselaphidae		
Pselopnus sp.	x	
Rhybaxis sp.	x	x
Pselaphus sp.		x
Carabidae		
Notomus sp.		x
Agonochila sp.	x	
Tenebrionidae		
Seirotrana crenicollis Pasc.	x	
Adelium sp.		x
Curculionidae		
Mandalotus sp.		x
Mallixus sylvicola (Oke.)	x	
Melandryidae		
Orchesia sp.		x
DIPTERA		
Culicidae	x	
Chironomidae	x	
Tipulidae	x	
Dolichopodidae	x	
Empidae	x	
Lauxaniidae	x	
Psychididae		x
Mycetophylidae		
Sciara sp.	x	x
Ceratopogonidae	x	
NEUROPTERA		
Hemerobiidae		
Micromus? tasmaniensis	x	
M. tasmaniensis Walk.		x
HYMENOPTERA		
Braconidae	x	
Belythidae	x	
Diaparidae	x	
LEPIDOPTERA		
Geometridae		
Geometrinae	x	
Boarmiinae	x	
Noctuidae	x	
TRICHOPTERA		
Leptoceridae		
Symphitoneuria sp.	x	

Identifications of insects by Mr. A. Nebois, Curator of Insects, National Museum of Victoria.